Virginia Tech

Unmanned Systems Group

The Unmanned Systems Group

www.unmanned.vt.edu

Promoting Unmanned Systems Research
and Collaboration at Virginia Tech

Virginia Tech

- **The University**
  - Virginia's public land-grant university
  - 110 Master's and Doctoral Programs
  - 28,000 students (26,000 in Blacksburg)
  - 6,500 graduate students (30% doctoral students)

- **The College of Engineering**
  - Undergraduate:
    - 15th among accredited engineering schools
    - 10th among public schools
  - Graduate: 8 departments ranked in Top 20

Unmanned Systems Capabilities

- **Virginia Tech's *Unmanned Systems* programs are unique**
  - Broad expertise
  - Internationally recognized programs in specific disciplines
- **Capabilities in all domains**
  - Ground vehicles
  - Underwater vehicles
  - Air vehicles
  - Space vehicles

Unmanned Underwater Vehicles

Platoons of Cooperating AUVs

The Virginia Tech miniature AUV

Principal Investigator:

Daniel J. Stilwell

Electrical and Computer Engineering

Sponsors:

NSF (CAREER)

ONR (Young Investigator Program)

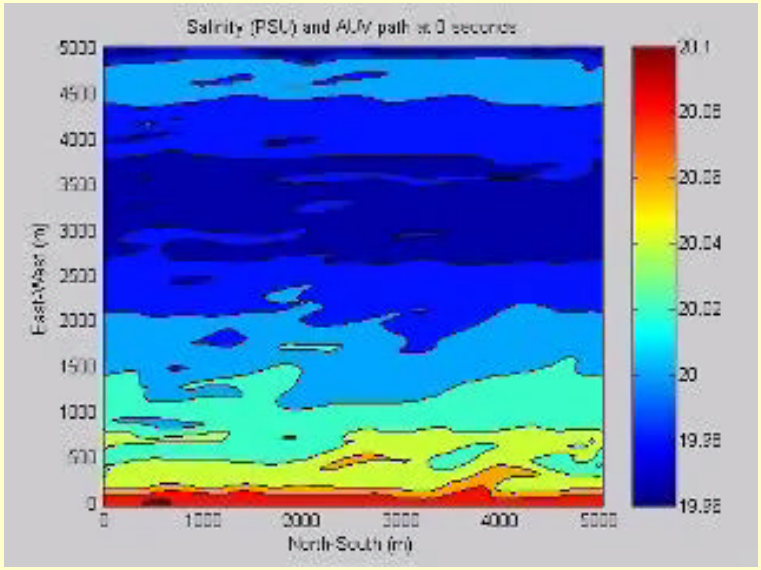
DARPA

Applications:

- Rapid, wide-area search and survey
- Harbor reconnaissance
- Sensor networks
- Environmental assessment

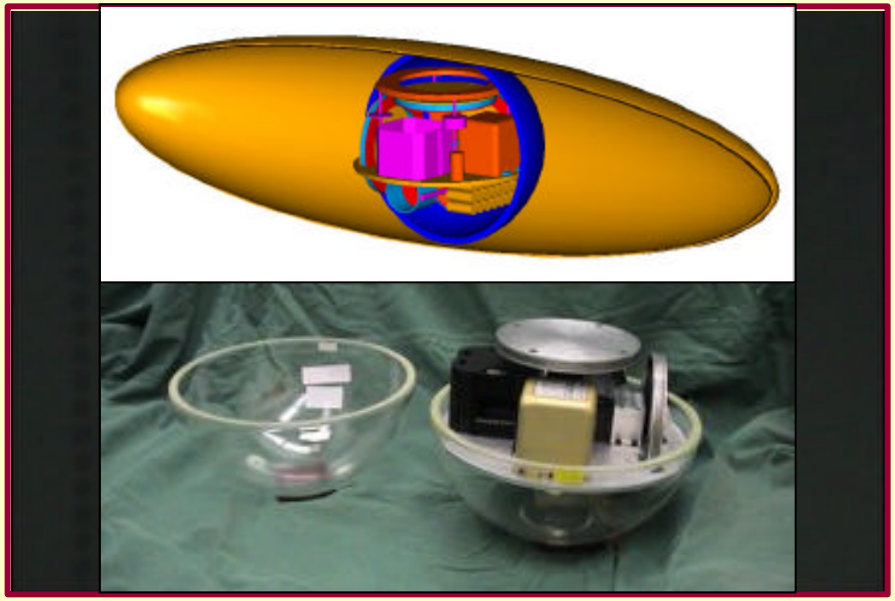
Approach:

- Multi-vehicle control and estimation
- Rigorous field trials (Virginia coast and Chesapeake Bay)



An simulated AUV follows a salinity contour

Nonlinear Control of Autonomous Underwater Vehicles (AUV's)



Global attitude control

Principal Investigator:

Craig Woolsey

Aerospace & Ocean Engineering

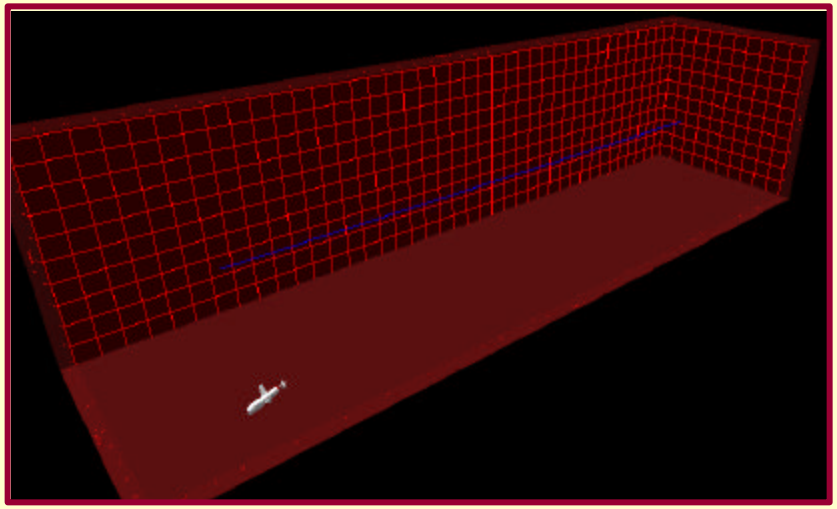
Sponsors:

NSF (Career Award; Collaborative Ocean Technology Development Grant)

ONR (Young Investigator Program)

Research Objectives:

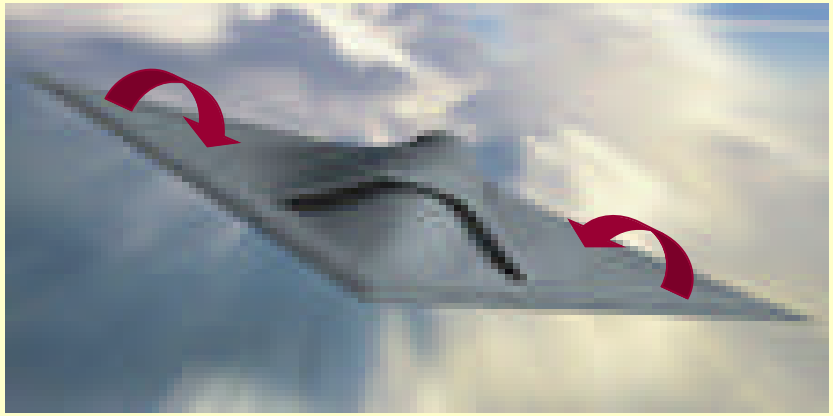
- Develop novel actuators and provably effective nonlinear control strategies for AUV's moving at very low speeds.
  - Increase performance envelope
  - Improve robustness and reliability
- Develop and field practical control technology for ocean scientists.



Global path following

Unmanned Aerial Vehicles

Adaptive Output Feedback Control for Autonomous Vehicles



Failure of one control surface can cause saturation of others during control reconfiguration.

Principal Investigator:

Naira Hovakimyan

Aerospace & Ocean Engineering

(Collaboration with E. Lavretsky, Boeing)

Sponsors:

AFOSR

Research Objectives:

- Adaptation to actuator failures in the presence of input constraints.
- Autonomous formation flight and aerial refueling.
- Control of nonlinear systems which are non-affine in the inputs.

Morphing Aircraft: Center for Intelligent Material Systems & Structures

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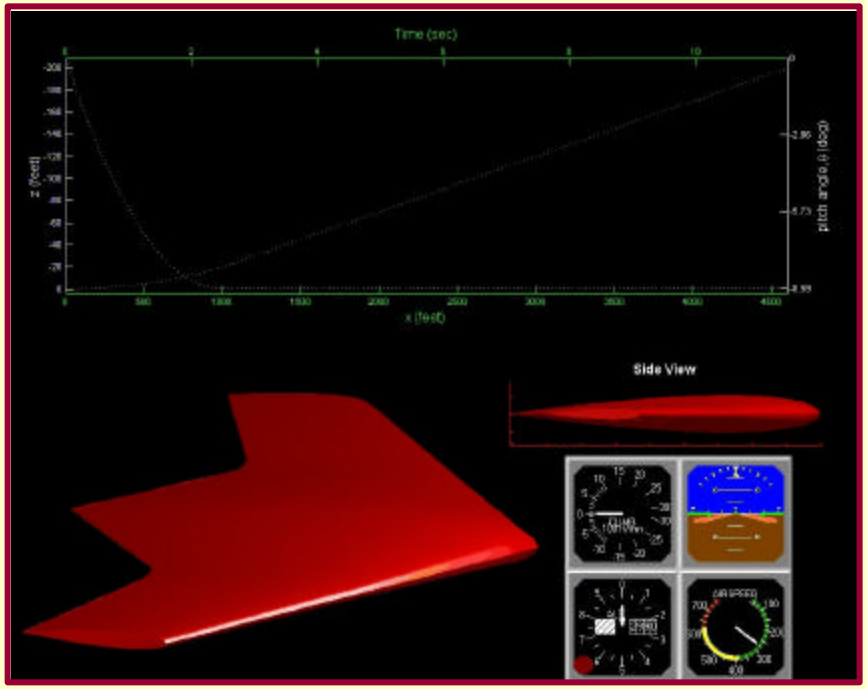


Principal Investigators:

Dan Inman, Harry Robertshaw
Mechanical Engineering

Bill Mason
Aerospace & Ocean Engineering

Sponsors:

DARPA/NASA

Research Objectives:

- Major military aircraft effectiveness increase
  - UAV applications for now
- Same airplane performs multiple roles -
  - "Hunter-Killer"

Approach:

- ***Change shape*** for each role via smart structures, materials and actuation
- ***Control*** both the shape change *and* flight

Autonomous Robust Aviation

NASA OV-10A aircraft used for flight tests

Runway edge detection

Principal Investigator:

Lynn Abbott

Electrical and Computer Engineering

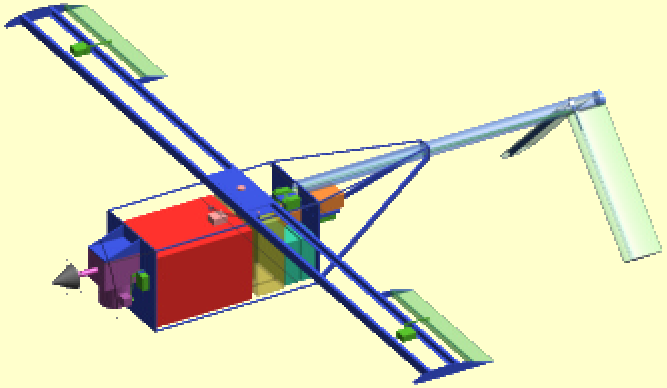
Sponsors:

NASA

Research Objectives:

- Develop autonomous or semiautonomous landing capability for General Aviation (GA)
- Locate runways in image sequences
- Integrate with other sensors and expand to entire flight sequence

UAV Designed and Flown



Student design: 50 pound payload, 5 hour cruise/loiter

Principal Investigator:

W.H. Mason

Aerospace & Ocean Engineering

Sponsors:

NASA

Lockheed Martin

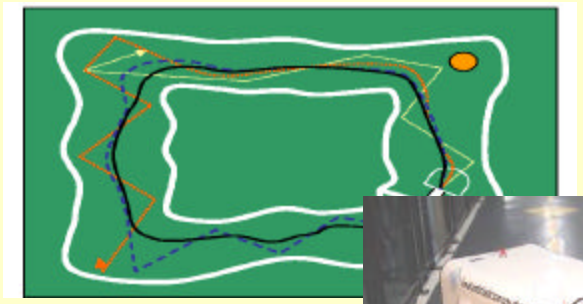
Research Objectives:

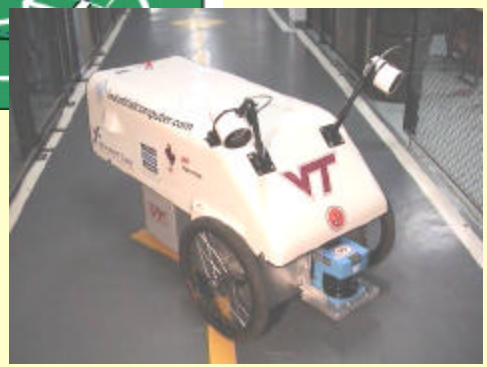
- Sensor platforms for forestry research
- Formation flight
- Small, inexpensive UAVs

A UAV designed for carry sensor for forest canopy research

Unmanned Ground Vehicles

Autonomous Navigation Research





Global Map Building

Research Objectives:

- Develop adaptive navigation strategies
- Create robust lane following computer vision algorithms
- Sensor fusion
- Fault tolerant system design
- Calibration and test methodologies for unmanned systems and sensors

Principal Investigator:

Charlie Reinholtz

Mechanical Engineering

Sponsors:

Honeywell
Industrial Computers
National Instruments

Benchmarking performance across vehicle platforms

Autonomous Continuous Haulage Systems (CHS's)

Conventional CHS (Courtesy DBT America, Inc.)

Research Objectives:

- Develop sensor systems and effective control strategies for CHS's moving underground.
- Demonstrate these systems and control strategies on a model CHS.
- Implement this technology on new user-developed mining equipment.

Principal Investigator:

Bob Sturges

Mechanical Engineering

(with Amnart Kanarat)

Sponsor:

DBT America

Approach:

- Sensor Systems: Adapt sensors to mining environment: dirty, rugged, explosion-proof.
- Modeling: Develop robust kinematic and dynamic system models. Validate driving rules with scale model prototypes.
- Control Design: Use new uncertainty modeling techniques for real-time path-finding and nonlinear control.

Unmanned Teleoperated Hydraulic Systems

Principal Investigator:

Al Wicks & Charlie Reinholtz

Dept. of Mechanical Engineering

Sponsors:

Naval Surface Warfare Center, Dahlgren

Case/New Holland

National Instruments

Research Objectives:

- Demonstrate Conversion for dual (on-board and remote) Operation
- Develop Low-Cost, Transferable Technology
- Evaluate Effectiveness of 2-D Interface
- Explore Electro-Hydraulic Control Issues
- Create Semi-Autonomous Front-End Loader
- Case Test Site Automation

Spacecraft

Design, Dynamics and Control of Formation Flying Spacecraft

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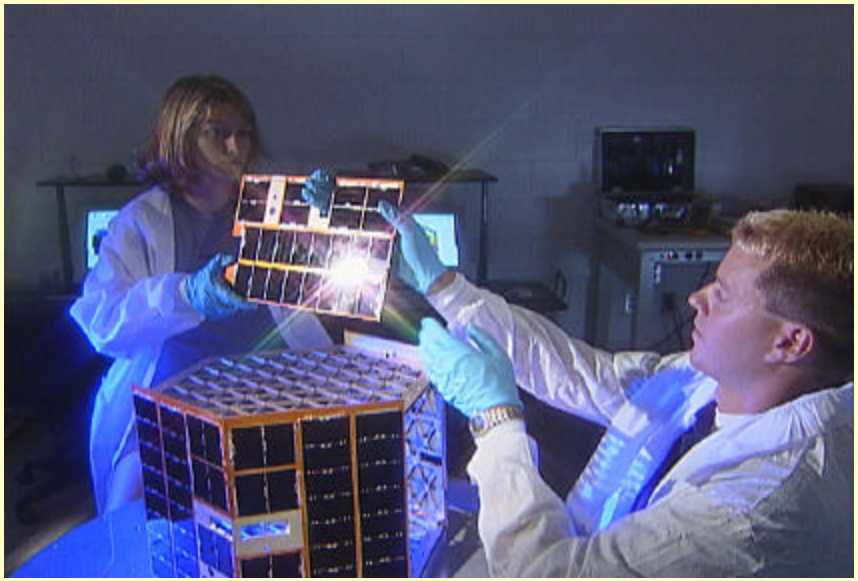


Research Objectives:

- Develop novel control strategies for clusters of spacecraft in cooperative missions.
- Demonstrate control strategies using spacecraft simulators and on-orbit student-built satellites.
- Educate next generation of space systems experts

Principal Investigator:

Chris Hall

Aerospace & Ocean Engineering

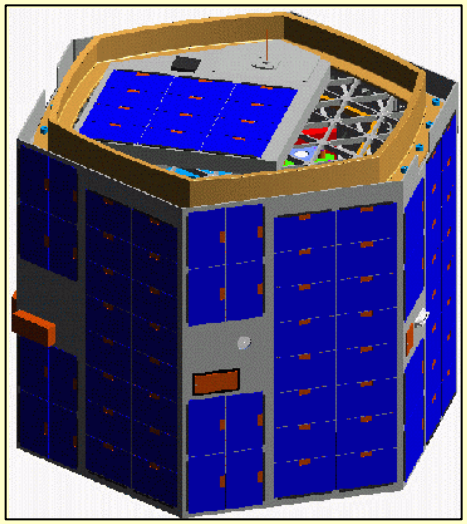
Sponsors:

Air Force Office of Scientific Research

Air Force Research Laboratory

National Science Foundation

NASA Goddard Space Flight Center



HokieSat

Supporting Programs

MAD Center
Human-Machine Interfaces

Multi-Disciplinary Analysis and Design Center for Advanced Vehicles

Interactive, Immersive Virtual Environments

Research Objectives:

- Perform multi-disciplinary design optimization (MDO) of advanced vehicles
- Develop and use variable complexity models to obtain optimal designs.
- Perform required research in fundamental science to support design optimization.

Research Objectives:

- Visualize real or simulated sensor data in an immersive VE
- Design and evaluate 3D user interfaces (3DUIs) for unmanned systems
- Investigate the use of information-rich VEs for combining perceptual/spatial data with abstract information

Wireless Communication

Virginia Tech

Unmanned Systems Group

Mobile and Portable Radio Research Group
(www.mprg.org)

Resources and Capabilities:

- RF propagation channel characterization
- Wireless system simulation
  (Emphasis on local area networks, microcellular communications, and macrocellular communications up to 30 GHz.)
- DSP hardware development

Center for Wireless Technology
(www.cwt.vt.edu)

Resources and Capabilities:

Integrative, state-of-the-art research programs to create innovations in

- wireless networking,
- embedded and broadband wireless systems

and related systems and components.

Intelligent Materials, Systems, and Structures

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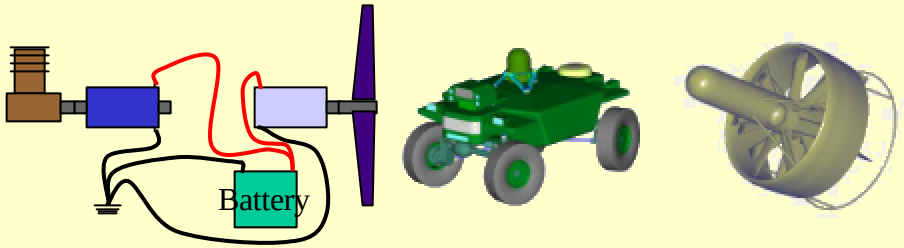
Center for Intelligent Materials, Systems and Structures
(www.cimss.vt.edu)



Hybrid Electric Propulsion Systems

Sample of Current Research:

- Design and analysis of smart systems and structures
- Active control and sensory systems for structural health monitoring
- Design of actuators, sensors, and hybrid control systems
- Adaptive wing designs for unmanned combat vehicles

Research Objectives:

- Integrate vehicle propulsion and electric energy storage subsystems.
- Demonstrate improved fuel economy and range, silent watch and stealth modes.
- Transfer new power system technology to the user community.
- Define the state-of-the-art, technical risks.

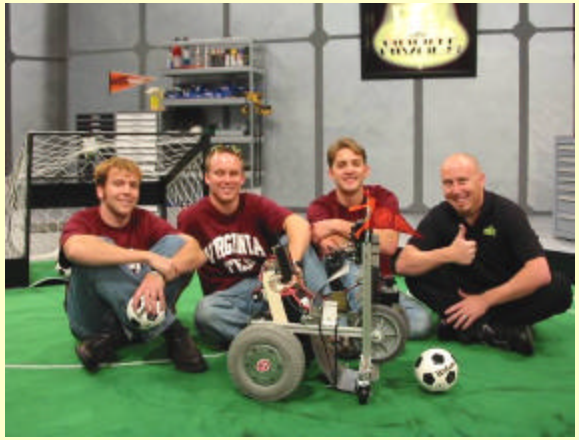
Student Design Teams

Design/Build/Fly Team

Autonomous Underwater Vehicle Team

Autonomous (Ground) Vehicle Team

Robot Rivals (DIY Network)

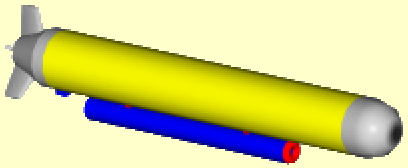


DARPA Grand Challenge

The FUTURE

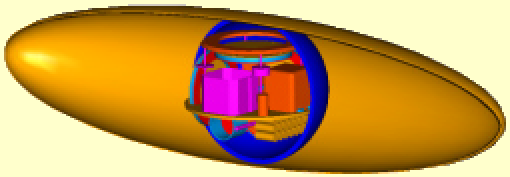
A center that simultaneously addresses the R&D needs of unmanned vehicle systems across autonomous air, land, sea and space systems

Center for Unmanned Vehicle Systems



Research Issues

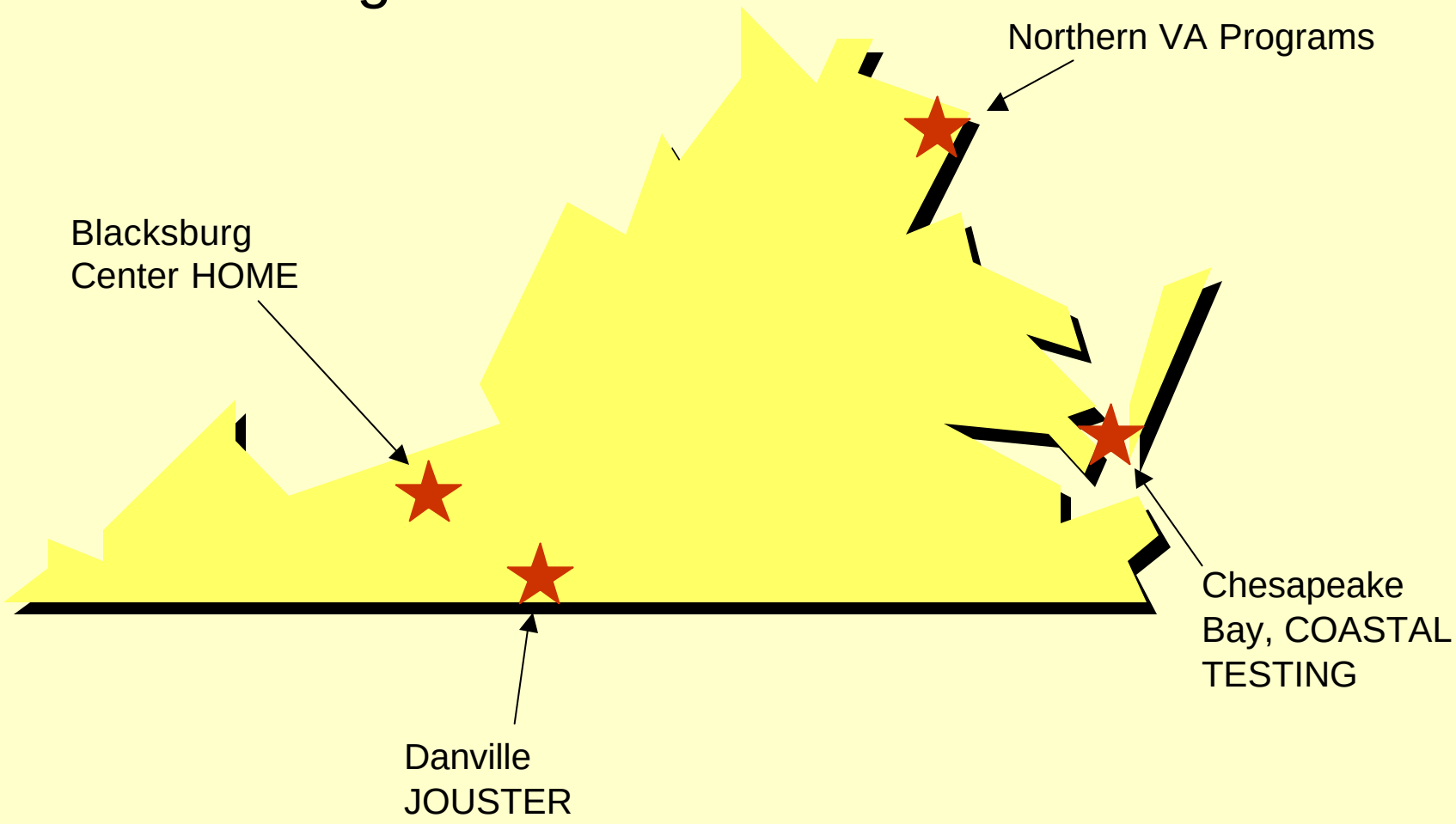
- VT is uniquely suited to address cross-disciplinary problems, e.g.,
  - Navigation and mapping
  - Multi-vehicle cooperation
  - Sensor networks
  - Human-Machine interfaces



Institute for Critical Technology and Applied Science

- Provides multi-use laboratory space
- Provides technical and administrative support
- Enables large inter-disciplinary programs

Center for Unmanned Vehicle Systems will utilize facilities throughout the Commonwealth



A University Putting Knowledge To Work.